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ABSTRACT

In this study, integration of art and science instruction was applied in an experimental computer art graphics class, as undergraduates learned geological concepts and processes through creating computer art graphics. The qualitative study concerning students' perception of integrative instruction was made from the students' point of view. Questionnaire answers revealed that creation of geology-related art production on the computer provided the students with confidence about their artistic abilities and helped them understand geological drawings, graphs, and geology lectures. Most of the students found beneficial and stimulating that they were not evaluated and could use and manipulate their knowledge of geology in an atmosphere of freedom and flexibility. In the quantitative study made from the teacher's point of view, dependent variables included mean score on the geology content achievement and art jurors' evaluations of the student artwork. Results showed a significant difference between mean scores on the laboratory grade and the course grade for the experimental and control groups. Jurors' evaluations correlated with the order of creating the subsequent science-related computer art graphics. Results suggest that the adoption of computer art graphics integration with science instruction provides opportunities for increasing students' understanding of scientific concepts, improves their performances in science, and enhances their artistic production. (Contains 15 references.) (JLB)

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ED 374 773

Anna Ursyn, University of Northern Colorado

Students' Perception of Computer Art Graphics

Integration of Art and Science

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Anna Ursyn, University of Northern Colorado

Students' perception of computer art graphics integration of art and science

Abstract

In this study, instructional procedures integrated art and science instruction with the use of computer art graphic. Integration of art and science was applied in an experimental computer art graphics class, as students learned geological concepts and processes through creating computer art graphics. They solved computer art graphic assignments inspired by scientific problems.

The qualitative study concerning students' perception of integrative instruction was made from the students' point of view. The questionnaire answers revealed that creation of geology-related art production on the computer provided the students with confidence about their artistic abilities and helped them understand geological drawings, graphs, and geology lectures. Most of the students found beneficial and stimulating that they were not evaluated and could freely use and manipulate their knowledge in geology in the atmosphere of freedom and flexibility.

In the quantitative study made from the teacher's point of view, the dependent variables included (a) mean score on the geology content achievement in form of grades, and (b) art jurors' evaluations of the student artwork in the form of a forced q-sort. An analysis of variance (with a posttest only approach) showed a significant difference between mean scores on the laboratory grade ($p<.019$) and the course grade ($p<.006$) for the experimental and control groups. Also, jurors' evaluations of the student artwork correlated with the order of creating the subsequent science-related computer art graphics.

The results of this study suggest that the adoption of computer art graphics integration with science instruction provides opportunities for increasing students' understanding of scientific concepts, improves their performance in science, and enhances their artistic production.

Objectives

The problem discussed in this study is possible approach to teaching computer art graphics in order to integrate and influence both science and art domains. The choice of the problem and the reason to explore this topic is based on a strong belief that creating computer art graphics may facilitate students' understanding of science and encourage them to create art in classroom environment. This study is a part of the work-in-progress which investigates the effects of art and science integration through instruction in computer art graphics, both with qualitative and quantitative approach.

The research topic for the ethnographic study is the students' response to integrative learning with the use of computer art graphics. The mode of inquiry is a study of students' answers to a questionnaire. The purpose of gathering qualitative data is in a need of information coming from the students' point of view and their opinion about the usefulness of this treatment and its possible improvements. This information was meant to help the author understand and discuss some of the reasons and mechanisms underlying positive changes in students' performance that occurred during the treatment.

The goal of the quantitative experimental research study is to investigate whether instructional programs in computer art graphics might enhance students' performance in the domains of both science and art and help them discover the correspondence of science problems and their visual references.

Theoretical framework

The theoretical framework for the study grows out of constructivist approach to developing knowledge by "a restructuring of reality through the activities of the subject" (Inhelder, 1977, p. 399). It is the construction of cognitive schemes, categories, concepts and structures that is important in learning (Bettencourt, 1989). When students create art inspired by a science problem, they are actively restructuring conceptions and broadening their way of thinking about science (Abshere, 1991). The theoretical framework for this research project is derived from recent advances in research on mental images in human cognition. Traditional learning is based on left hemisphere operations and verbal information processing, while recent advances in cognitive science confirm the importance of mental imagery as a form of nonverbal processing (Cornoldi & McDaniel, 1991). Research results indicate the development of visual representations of scientific concepts as crucial strategy for learning, memorizing, and problem solving (Logie & Denis, 1991, Pankratius, 1990). The described approach to teaching computer graphics is based on presumption that mental representations of visual objects, information, concrete and abstract concepts support working memory. Encoding and maintenance of information taking place in visual and visuo-spatial working memory make possible the construction of mental visualization of objects, thus facilitating problem-solving, and enhancing content and nature of mental imagery in cognition and learning.

The rationale for this questionnaire analysis is in evaluating a grounded theory generated from data (Glaser & Strauss, 1967) concerning non stressful environment using computerized media. The importance of analyzing students' perceptions about computer art

implementation to science instruction results from advances in computerized instructional technologies and pervasive use of visualization in teaching science. Cognitive approaches to mental imagery provide a new set of relatively valid methods of research likely to produce more information about the processes of understanding, encoding, and memorizing scientific concepts. The potential of the computer to enhance thinking processes and change the access to knowledge has been acknowledged and explored by Pappert (1980, 1988). Mokros and Tinker (1987) suggested a link between students' graphing skills and their ability to understand scientific relations. Some cross-disciplinary development programs should be mentioned, intended to address a new mode of scientific inquiry (Mones-Hattal, O'Connell, and Sokolove, 1990; Computer Strategies Across Curriculum, 1991), initiated in order to develop new curricula of computer graphics as an interactive instrument in art education (Wilson, 1993; Brown, 1993). Assessment of such far reaching impact could only be done in terms of the improvement in students' understanding and learning. The conceptual framework for studying students' attitude is in author's perceiving of the importance of activating a participant process of learning (Yopo, 1989). Through creating computer art, students are creating images of the things they are studying.

The far reaching impact of integrative approach to computer graphics-assisted learning environment may be in learner-centered improvement over existing practice of teaching. Based on the tracking of the research line associated with this research concerns, one may often notice the researchers' approach focusing on visualizing ideas in form of presenting data in graphical explanative form, but it is hard to find a research supporting the understanding of science through artistic expression. This project may be considered the important departure from existing practice in computer graphics instruction.

I. Qualitative Study – From the Student's Point of View

Methods and techniques

This study is based on long term observation from computer art graphics classes designed for non-art major students taking concurrently a physical geology class. In those

classes, art and science integration was applied, as students learned geology through creating computer art graphics. In the art assignments, the results of active investigations of physical and natural phenomena served as an inspiration for creating computer generated art. Students participating in the course solved computer art graphics assignments inspired by scientific problems where the appealing and stimulating visual references were matched with a curricular context in science.

Data source

Information about the students' response to the experimental course have been collected after completion of both the computer art graphics course and a concurrent geology course. The questionnaire consisted of 21 questions. It was prepared in order to perceive some information reflecting the content of the course and results of the treatment from the part of the students. It also permitted to gain some information about the students and their background. The students were asked to fill out the questionnaire on the voluntary basis during the last class sessions, and it was up to the students to sign the form and release their name. The students were informed only generally about the purpose of the study as an answer to researchers' interest in instructional procedures. The students were free to say anything they wanted; they were graded for the computer art courses on the basis of their attendance and the mere completion of the drawings. All students were assumed a place in this ethnographic study, to offset possible dominance by a few. In fact, all 49 persons (out of 53 course participants) that were present at the last session meetings responded to and returned the questionnaire.

Results

Answers were examined for evidence in students' comments of their reaction to the experimental instruction. Questionnaire items and the content analysis of students' comments are presented in Appendix A. A majority of the students (63%) did not have any experience in computer graphics and did not take any art classes (69%). According to students' responses, geology-related art production on the computer provided the great majority of the students (78%) with confidence about their artistic abilities, as most of them (92%) liked their

artwork created in this class. Most of the students (96%) found beneficial and stimulating that they were not evaluated, neither on geology knowledge nor on art quality. The students (80%) found stimulating they could freely use and manipulate their knowledge in geology. Class activities helped 77% of students understand geological drawings and graphs, and helped 57% of students understand geology lectures. When asked what was good about the course, 55% of students stressed the atmosphere of freedom and flexibility, relaxation without stress and criticism, while 35% pointed out the use of computers and graphic software.

II. Quantitative Study – From the Teacher's Point of View

The issues of integration of science concepts into the art creation and students' use of art graphics for learning science were inseparately intertwined in this study. The major purpose of this study was to determine if students' achievement in geology content could be improved by creating computer art graphics with visual references to science concepts, and how students' computer generated artwork may be influenced by their science experiences.

Methods and techniques

The study was conducted with 53 volunteer students enrolled in a geology course in the Fall semester 1992. A group of 188 students, that means, most of the remaining students enrolled in the same physical geology class, was identified as the control group. The independent variable was a set of computer art graphic assignments where students correlated geological processes and facts with their visual artistic references. The dependent variables included (a) mean score of the geology content achievement in form of grades, and (b) art jurors' evaluations of the student artwork in the form of a forced q-sort. The groups comparison in achievement in form of the geology content grade scores was analyzed using a posttest only control group design. Perceptions of the experts in visual arts and art criticism about quality of students' portfolios were examined with the structured forced q-sort method.

The methodology of the q-sort allows for a study of human subjectivity without sacrifying the power of statistical analysis. The q-sorting of visual materials was applied, to answer how the levels of the computer art quality evaluation related to the progress in computer graphics instruction.

Data source

Data were collected in several phases. (a) Students' computer art graphics were collected. (b) Students' drawings were rated by the art jurors. The evaluations of students' artwork done by the art jurors in the form of a forced q-sort were used to determine effects of the treatment on students' computer art graphics creation. (c) Students' achievement in geology content in form of grades was examined. Data were analyzed with the use of an analysis of variance and a Spearman correlation. The 0.5 level was accepted as a criterion of significance.

Results

As a result of the study, significant difference was found, in the mean score of geology content achievement in form of grades, for the experimental group completing the science-related computer art assignments and the control group. An analysis of variance (with a posttest only approach) showed a significant difference between groups for the laboratory grade ($p<.019$) and the course grade ($p<.006$) – with the experimental means higher than control means (Appendix B). Item analysis of the q-sort data allowed for computing the correlation between jurors' ratings of the students' computer art graphics and the order of subsequent science-related computer art graphics assignments performed. Jurors' evaluations of the students' artwork in the form of a forced q-sort correlated with the order of computer art creation, with the Spearman correlation coefficient equal to 0.745, which was significant, with $p<.008$. The results of this part of the study indicated that building representations of science concepts through computer art graphics enhanced students' achievement both in science and in art.

Conclusions

Students' perceptions of integrative instruction in computer art graphics reveal students' intrinsic motivation, considerable increase in their self confidence in art, their improved understanding of geology concepts, and active approach to problem solving and visual thinking about science issues.

The results of the quantitative part of the study indicate that building representations of science concepts through computer art graphics may enhance students' achievement, both in science and in art. The findings suggest that computer art graphics may be helpful as an instructional tool for improving both the quality of students' artwork and their understanding of science concepts.

The educational and scientific implications

Questions examined in this study may concern the learning environment for the entire area of computer graphics instruction. The development of students' intrinsic motivation, the increase of self confidence and contentment in their active approach to problem solving and visual thinking about science issues provide opportunities for improving students' understanding of scientific concepts. It may be concluded, findings concerning the learning environment in the area of computer graphics instruction could be instrumental in developing curricula for integrated courses in art, science and computer graphics. The study provides implications for exploring the instructional utilization of computer art graphics in visual problem solving.

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APPENDIX A

Questionnaire Items and Answers' Analysis

Please answer the questions and be sure your answers will not affect you and will not be used in any unfavorable way.

Question Number and Content — Number and Percentage of Answers: YES NO and a A Content Analysis of Students' Comments

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1. Did you have any experience in computer graphics?

18 (36.73%) 31 (63.27%)

Analysis of the answers to the item #1 on the surface level revealed that 18 persons (37%) declared some experience in computer graphics, while more than a half of the students, that means, 31 persons (63%) did not have any computer graphics experience. Further elaboration on the comments offered by the respondents did not allow to develop classification of the computer graphics experience into the formal schooling in computer graphics and non professional activities, as nobody reported any computer graphics class completed, nor declared any professional work or job related to computer graphics. The answers were unspecific in respect to the kinds of hardware and software used by the respondents in the past, with the exception of two persons who claimed they did use a CAD, the Appleworks, and an unspecified desktop publishing program. Also, the character of past experiences with computer graphics has not been specified by the respondents. They did not revealed any past interest in computer art graphics and any connection of their past activities with creation of computer art graphics. Therefore, responses to the item #1 concerning computer graphics experience may be clarified as non professional, informal contact that 37% of persons had with some design and drafting oriented software.

2.Did you take any art classes? If you do, list them.

15 (30.61%) 34 (69.39%)

The greater part of the students, that means, 34 persons (69% of the respondents) did not take any art classes before they accepted their participation in the computer art graphics class under study. Further elaboration of responses declaring some previous participation in art classes allowed to develop a classification scheme in order to further characterize students' experience in the arts. Beginning Drawing classes were taken by 6 persons (12%, 1 of them concurrently with the course under study), while Sculpture and 3-D Art classes were taken by 3 persons (6%), one of them concurrently with the course under study. Other responses are dispersed into Art History and Art Appreciation (3 persons), Design class (1 person, concurrently with the course under study), problem in color (1 person), photography (1 person) , and Art classes at a High School level (2 persons, 8%).Classification of the art-related persons and persons uninterested in art could not been developed on the basis of this questionnaire, as nobody declared any professional nor unprofessional activity in the field of art, except one person who mentioned sketching, with a meaningful comment "I can do it, but I can't spell it" showing the spontaneous, relaxing approach to this activity. Generally, one may clarify the scheme of the answers as characterizing the students as having fairly no experience in the arts.

3.Which situation do you prefer: working on a computer by yourself, or in a team of two classmates?

28 (51.85%) 26 (48.15%)

In fact, it could be counted as 57% answers 'yes' and 53% answers 'no', as some answered: 'both'. Content analysis at the surface level of the students' approach to individual versus co-operative work on a computer showed the answers split almost into halves: 28 versus 26 persons (52% versus 48% of the respondents), with 6 persons (12%) declaring their approval of both styles of work on a computer and one person answering "doesn't matter". Further elaboration on the nature of the comments revealed students' attitudes influencing students' choices. Three respondents (6%) who liked to work in a team, declared educational advantages coming from the team work, while three other persons liked to share ideas and schemes. From the 28 proponents of

individual style of work, sometimes stressed strongly their need to work alone. Generally, as directions of answers were split in halves, those answers did not allow for any clarification whether individual or team style of work was preferred by the students.

4.While working in a team, did you discuss more the artistic or geology aspects of the assignment?

ART 20 (44.44%) GEO 25 (55.56%)

Working in a team allows for a discussion of the artistic and/or geology aspects of the assignment. The question #4 was put in order to clarify students' perception of the content of their discussions. Also in this case, answers were split almost into halves, with 20 persons (44%) declaring artistic content of their team discussions, and 25 (56%) reporting their interest in geology themes for discussions. The answers of 12 persons (24%) were unspecified, some of them emphasizing the integrative approach to visualization of the geology concepts. Other 4 persons (8%) stressed their individual approach to the themes. One student expressed informal character of talking with the classmates, one stressed the role of the personality of the classmate, and two persons (4%) mentioned possible computer applications as a theme of discussions.

5. How do you feel about drawing: before the course? after the course?

Students' feelings about the drawing have been always positive in 29% of answers (14 students). Nineteen persons (39%) changed their approach to drawing after the course, because 8 persons (16%) felt they learned more during the class, and 11 persons (22%) liked drawing more than before. Ten students (20%) responded in a negative way, as 2 persons definitely didn't like drawing, and 8 persons declared that they have been feeling uncomfortably frustrated being not good at drawing. The remaining 6 students (12%) were indifferent, or their remarks did not relate to their feelings about drawing, for example, one person analyzed drawing as a way of visual thinking and communicating information, while somebody else gained more respect for artists.

6. Do you think your drawings are better when you use a pencil, or a mouse? Why?

28 (56.0%) 22 (44.0%)

Question #6 discussed students' preferences for the use or a pencil or a mouse. The majority of the students (28 persons, 56%) liked their drawings better when they used a pencil, because of more control with it (40% of answers), feeling of freedom, sensitivity, and natural character of its use. Twenty two persons (44%) preferred a mouse, and stressed the options, freedom to change or erase, and the efficiency of this tool, as it can do perfect geometric shapes. Also, that one can draw faster, without muscle strain, and see mistakes easily. Students' confidence with the use of a pencil may result from their small experience with computer graphics (see answers to question #1). It was directly confirmed by three persons (6%); also, a feeling of having better control over a pencil may suggest better experience with this tool.

7. Do you feel more confident about your artistic abilities after creating art on the computer (having computer memory, save as, revert to save, copy and paste, paste to selection, etc., at your command)?

38 (77.55%) 11 (22.45%)

After gaining some experience with computer graphics, the great majority of the students (38 persons, 78%) declared, some of them very strongly, their better self confidence about their own artistic abilities. Some of the respondents stressed the possibility to experiment and to change things on a computer. Those who did not feel better about their creative abilities (11 persons, 22%), evaluated their drawings as not very good, found drawing on a computer very difficult, or preferred hand drawing to the use of computer art graphics.

8. Do you like your artwork created in this class? Which particular artwork do you consider the best?

45 (91.84%) 4 (8.16%)

As an answer for the question 8, most of the students (45 persons, 92%) liked their art, while 4 persons (8%) did not like it. When asked about a particular artwork they considered the best,

7 persons (14%) named landscapes (but only 3 of them, that means, 6%, defined them as landscapes), 4 persons (8%) preferred still life, especially the rock still life, 4 persons (8%) mentioned "A Journey to the Center of the Earth", 3 persons (6%) named abstract works as favorite ones. Twenty persons (40%) did not name any specific work. Eleven persons (22%) out of those did not have any preferences: 4 persons (8%) declared they liked most of their works, other persons preferred some kinds of work, for example, layering techniques with patterns, works done by themselves, team effort works, etc. Three out of those 4 persons who declared they did not like their art generally, named nevertheless their favorite works they liked most.

9. What did you expect of yourself? Did you think you could do the artwork you have created?

28 (57.14%) 11 (22.45%)

When asked what did they expect of themselves and whether they expected they could do the artwork they have created, 28 persons (57%) confirmed their confidence about own artistic abilities, while 2 persons (4%) were surprised with their own results which had surpassed their expectations. The remaining 11 persons (22%) did not offer any definite response about their expectations about own artistic potential. When asked about expectations of themselves, 9 persons (18%) stressed their interest in computers and computer graphics, 6 persons (12%) described their expectations in art, 4 persons (8%) declared their readiness to do the best they could, and some persons did not know what they expected from themselves or had low expectations. Some persons did not add 'yes or no' answers to their comments.

10. Did the activities in this class affect in any way your listening to Dr. Jim McClurg lectures? If yes, how?

28 (57.14%) 42.86%)

An affirmative response to a question #10 (whether activities in the computer art graphics class affected the way the students listened the lectures delivered by the regular geology class instructor) was given by 28 students (57%), while 21 students (43%) did not see any influence of class activities. Those who confirmed positive influence of those activities, stressed the role of better visualization of the geological material (10 persons, 20%), its better understanding and interpretation (5 persons, 10%), review and reinforcement of the material (5 persons). Someone stressed the advantage of another application of what was learned in the geology class, one student declared she developed an active way of listening, and another person declared that the course opened his eyes to Geology.

11. Did the activities in this class help you understand Dr. McClurg's drawings and graphs?

37 (77.08%) 11 (22.92%)

When asked whether computer art graphics activities helped them understand drawings and graphs made by the regular geology class instructor, 37 students (77%) answered positively, while 11 persons (23%) did not see such effect. In their comments, the some students stressed their better understanding and imagination and easier visualization of concepts.

12. In this class, you haven't been evaluated: neither on your knowledge in geology nor on your art quality, and can get an "A" merely for the completion of all assignments. Did you like it? How did it influence your work?

47 (95.92%) 0 (0%)

In answer to item 12, 47 persons (96%) answered that they liked not being evaluated, and the remaining two persons (4%) have only stressed that they were not influenced by not being evaluated for their work. In their comments, students claimed they were more relaxed and creative, and thus more adventurous, and could make their own decisions, when they were not competing for grades. This situation was considered less stressful and permitted more drastic expression, so their drawings were more dramatic. Most of the students expressed their strong contentment that this situation influenced them for good; however five students said it did not influenced their attitude and work, as they knew they had to do every assignment well. Some people said that by liking the class they could work for their own benefit, enjoy working on a computer, work on a piece until they felt happy, so they wanted try more, and only had to worry about pleasing themselves, which made them feeling more creative.

13. Did you show your artwork at home or to your friends? How did their interaction affect you?

25 (51.02%) 24 (48.98%)

In item 13, answers were split in halves, with 25 persons (51%) who did show their artwork, and 24 persons (49%) who did not. Seven persons from those who showed their artwork felt unaffected by the reaction of the perceivers, and some other persons said the viewers laughed at the artistic abilities of the authors of the drawings or were indifferent and uninterested. For one person, artwork was personal, so she preferred to keep it to herself. Sixteen persons (33%) were given an interested and favorable reaction from the viewers, and most of them were feeling more confident and proud.

14. Please assign numbers to the assignments, starting with the theme you liked best (1 for the best, 12 for the worst one).

Title of the assignment	Number of students assigning a given number											
	1	2	3	4	5	6	7	8	9	10	11	12
A Trip to the Center of the Earth	9	7	6	4	3	1	2	0	3	2	4	6
Minerals, Crystals, an Interior of a Cave	2	7	4	7	2	5	1	2	2	6	6	2
The Rock Cycle	3	1	4	4	4	1	2	4	5	5	5	7
Sediments in Lakes, Streams, and Swamps	5	6	4	2	5	2	6	3	5	4	5	2
Metamorphic Rocks. An Ant Eye's Perspective	2	2	3	5	4	5	4	5	5	4	5	2
A Still Life Drawing with Rocks	8	5	4	0	3	5	5	3	4	3	2	5
The Geologic Time as a Landscape	2	5	3	6	5	8	5	3	1	6	0	2
Imagine a Landscape from the Map	5	2	2	7	3	6	5	5	5	3	2	0
A bird's-eye View Landscape	6	5	6	4	4	3	2	5	2	3	4	2
Facies Map: You Are the Owner of the Land	4	3	3	2	5	5	5	9	1	2	6	1
Changing the Scale: Draw a Mountain, Draw a Rock	1	1	2	4	3	2	4	2	13	5	3	5
Faults and Folds: a Playdough	2	4	5	3	4	2	5	3	1	3	2	12

In an item 14, the students were asked to assign numbers to the assignments, starting with the theme they liked best. After summarizing the numbers of ratings assigned by all the students, it could be stated that the assignment "A Trip to the Center of the Earth", "The Geologic Time as a Landscape", and the assignment "A Bird's-eye View Landscape" were liked the best, while assignments "Changing the Scale: Draw a Mountain, Draw a Rock" and "The Rock Cycle" were liked the least.

The data were rearranged in groups, with assignments rated 1-6 in a column 3 and assignments rated 7-12 in a column 4; ratings given by all the students for the assignments are in a column 1 (based on first six ratings) and in a column 4 (based on second six ratings).

Title of the assignment	Final Rating	Number of students assigning a rating 1 – 6	7 – 12	Final Rating
Column	1	2	3	4
A Trip to the Center of the Earth	1	30	17	1-2
Minerals, Crystals, an Interior of a Cave	4	27	19	4
The Rock Cycle	11	17	28	11
Sediments in Lakes, Streams, and Swamps	7	24	25	8-9
Metamorphic Rocks. An Ant Eye's Perspective	9	21	25	8-9
A Still Life Drawing with Rocks	5-6	25	22	6
The Geologic Time as a Landscape	2	29	17	1-2
Imagine a Landscape from the Map	5-6	25	20	5
A bird's-eye View Landscape	3	28	18	3
Facies Map: You Are the Owner of the Land	8	22	24	7
Changing the Scale: Draw a Mountain, Draw a Rock	12	13	32	12
Faults and Folds: a Playdough	10	20	26	10

15. Describe shortly this class: what did you do and how, during all meetings in general.

For 21persons (43%), the important feature of this class was working on a computer and with computer graphics. Thirteen persons (27%) answered they were constructing drawings, but only 3 (6%) persons characterized their work as artistic, 2 (4%) persons stressed the importance of using imagination, and one called it 'intuitive drawing'. For 11 (22%) persons, the important goal was to get an idea, then work on it, modify and experiment, using without intimidation different perceptions and interpretations. Some persons (7, 14%) stressed they learned more or understood better through experimentation, and thus got different perception on geology by using and interpreting knowledge, discussing ideas, or creating geologic formations and events on the screen. However, 4 (8%) persons just did what was said to be done. Two persons did not respond.

16. Have you been stimulated to use and manipulate your knowledge by the fact that you did not obtain Geology instruction in this class?

39 (79.59%) 8 (16.33%)

In answer to question #16, many students (39 persons, 80%) answered 'yes', and 8 students (16%) said 'no', while 2 persons (4%) did not answer. In their comments, 4 persons told they used geology knowledge, one stressed the use of computer knowledge, others were stimulated to read and think and understand more and to know how much they already knew.

17. During Dr. McClurg's lecture, did you try to anticipate your visual and/or on the computer approach the theme, or what kind of assignment could you expect?

23 (46.94%) 24 (48.98%)

The answers were split, with 23 persons (47%) saying 'yes', and 24 persons (49%) saying 'not', with 2 persons (4%) not responding. Those who answered positively, stressed close relationship of assignments to lecture topics encouraging to think during lecture and test students' own understanding of the subject matter.

18. Please develop your own assignment for this class.

In item #18, most of students' answers related directly to geology, disregarding art- or computer graphics-related approach. Ten persons did not develop any assignment project.

19. What was good about the course?

Most frequent answer (27 persons, 55%) related to the atmosphere of freedom and flexibility, relaxation without stress and criticism, playing and fun. Computer and computer graphics practice was stressed by 17 persons (35%), while 2 (4%) persons stressed their involvement in art, 5 persons (10%) in geology, and 4 were interested in integrated approach to art, computers and geology. For 6 persons (12%), the absence of grading and homework was important. Everybody answered this question.

20. What was not so good about the course?

Ten persons (20%) answered that two hours, instead of normal 1,5 hour class, was too long, while 4 persons (8%) needed more time. Four persons complained it was a night class, 4 persons considered hard to do own solutions, 3 (6%) persons were bored. Four persons complained that they had sometimes to share the computer, and they had poor access to the black and white printer and no access to a color printer. Five persons (10%) did not respond.

21. There wasn't much regular instruction in art. Did you feel confident developing your artwork in your own style?

44 (89.80%) 1 (2.04%)

When asked if they were feeling confident not being instructed in art and developing their artwork in their own style, 44 persons (90%) answered 'yes', 1 person (2%) said 'no', and 4 persons (8%) answered 'partially'. In their comments, students expressed their growing confidence, in spite of the fact they did not feel artistic.

Would you like to have your name included into the acknowledgements for publication consideration? Thank you for your cooperation during this experimental course. Sign and date here if you wish to do so.

When asked if the students wish to sign the questionnaire and if they like to have their names included into acknowledgements, 28 persons (57%) let to do it, while 17 (35%) did not, and 6 persons (12%) did not answer.

APPENDIX B

ONE-WAY ANALYSIS OF VARIANCE

LABORATORY AND COURSE GRADES IN GEOLOGY

Dependent variables	Independent Variables				
	Ss	df	MS	F	p
Lab Grade*					
Between Ss	7.22	1	7.22	5.60	.019
Within Ss	289.96	225	1.29		
Course Grade**					
Between Ss	11.11	1	11.11	7.68	.006
Within Ss	345.72	239	1.45		

* Cell Means: Experimental Group 3.08 (n=50)
Control Group 2.65 (n=177)

** Cell Means: Experimental Group 2.98 (n=53)
Control Group 2.46 (n=188)